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FINE POWDER MANUFACTURING APPARATUS USING A LASER

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Claim

Fine powder manufacturing apparatus using a laser with a reaction chamber, plural gas injection nozzles that inject a reaction gas and that are located on a wall of the reaction chamber, and plural filters that collect the fine powder and that are located on the wall surface facing said nozzles of the reaction chamber; characterized in that a laser beam successively passes through an area directly above each gas injection nozzle in order.

Detailed explanation of the design

Industrial application field

The present design pertains to an improvement for a fine powder manufacturing apparatus using a laser.

Prior art

Figure 2 is a diagram illustrating a fine powder manufacturing apparatus using a laser of the prior art.

In the figure, (1) represents a reaction chamber. Two optical windows (2_1) and (2_2) are arranged opposite each other on the side portions of said reaction chamber. Gas injection nozzle (5) for injecting reaction gas (SiH_4, NH_3, etc.) (3) and inert gas (Ar, etc.) (4) are arranged at the bottom of said reaction chamber (1). Said gas injection nozzle (5) is made up of first cylindrical nozzle (6) for injecting reaction gas (3) and second cylindrical nozzle (7) for injecting inert gas (4) that is formed concentrically around said first nozzle (6). Filter (9) for collecting the generated powder (Si_3N_4, etc.) (8) is arranged on the ceiling of said apparatus main body (1) opposite said first nozzle (5). Also, damper (10) is arranged near optical window (2_2) outside reaction chamber (1).

In the apparatus with the aforementioned constitution, reaction gas (3) is ejected from first nozzle (6), and a reaction is induced by a laser beam (CO_2 laser beam or the like) (11) whose wavelength matches the absorption wavelength of said reaction gas (3), and which passes through optical window (2_1), to produce said powder (8). Also, inert gas (4) is injected from said second nozzle (7) to entrain said powder (8) to filter (9) for collection.

Problems to be solved by the device

However, the aforementioned conventional apparatus has the following disadvantages.

(1) The laser energy not absorbed and used in the reaction is absorbed by damper (10) as thermal energy and wasted. The energy efficiency is therefore low.

(2) In each operation, it is only possible to manufacture a single type of powder made up of particles of one side.

The purpose of the present design is to solve the aforementioned problems of the conventional methods by providing a fine powder manufacturing apparatus using a laser characterized by improved energy efficiency and the ability to manufacture powder with different particle sizes and compositions in a single apparatus.

Problems to be solved by the invention

According to the present design, the aforementioned purpose is realized by a fine powder manufacturing apparatus using a laser characterized by a reaction chamber, plural gas injection nozzles that inject a reaction gas and that are located on a wall of the reaction chamber, plural filters that collect the fine powder and that are located on the wall surface facing said nozzles of the reaction chamber, and a laser beam that successively passes through the region directly above each gas injection nozzle.

Operation

In the fine powder manufacturing apparatus using a laser of the present design, the following two cases are considered.

(1) High laser output power:

Since plural gas injection nozzles and plural filters for collecting the powder are arranged in pairs, any excess laser energy can be utilized, so that the energy efficiency is increased. At the same time, by changing the injection pressure of said nozzles, it is possible to change the powder particle size, and, by changing the type of reaction gas, it is possible to change the composition of the powder.

(2) Low laser output power:

In this case, it is possible to focus the laser beam to realize the effects of said point (1) by arranging condensing lenses or concave mirrors between plural gas injection nozzles.

Application examples

In the following, an application example of the present design will be explained with reference to Figure 1. Also, in this application example, the laser energy is assumed to be high.

In this figure, (21) represents a reaction chamber. Two optical windows (22_1) and (22_2) are arranged on the side portions of said reaction chamber (21). Plural gas injection nozzles (25_1), (25_2)...(25_n) for ejecting reaction gas (23) and inert gas (24) are arranged on the bottom of said reaction chamber (21). Said gas injection nozzles (25_1)~(25_n) are made up of first cylindrical nozzles (26_1)~(26_n) for ejecting the reaction gas (23) and second cylindrical nozzles (27_1)~(27_n) for ejecting reaction gas (23) that are concentric with respect to said first nozzles. Filters (29_1)~(29_n) for collecting the formed powder (Si_3N_4 or the like) (28) are arranged at positions corresponding to said first nozzles (25_1)~(25_n), respectively on the ceiling of said reaction chamber (21). Also, damper (30) is arranged on the outside of reaction chamber (1) near optical window (22_2).

In the device with the aforementioned constitution, a gas mixture of SiH_4 and NH_3 is used as reaction gas (23); Ar is used as inert gas (2a); and a CO_2 laser beam (with wavelength at 10.6 μm) is used as laser beam (31). The CO_2 laser beam is absorbed by reaction gas (23) ejected from gas injection nozzles (24), inducing the following reaction

$$3S_iH_4 + 4NH_3 \rightarrow Si_3N_4 + 12H_2 \qquad (1)$$

to form Si_3N_4 fine powder. Then, the formed fine powder is entrained by inert gas (24) to filters (29_1)~(29_n) that collect the fine powder.

According to the present design, gas injection nozzles (25_1)~(25_n) and filters (29_1)~(29_n) are arranged in pairs side by side. Consequently, any excess energy can be used thereby increasing the energy efficiency. Also, by changing the injection pressure of reaction gas (23) of gas injection nozzles (25_1)~(25_n), it is possible to change the particle size of the powder. Also, by changing the type of reaction gas (23), it is possible to change the composition of the powder. In summary, it is possible to manufacture many types of fine powders with a single apparatus. Consequently, the productivity is improved.

In the aforementioned application example, the laser energy was assumed to be high. The laser power density required to drive the reaction of said formula (1) is about 10^5 W/cm^2. Consequently, when the laser energy is not high, the constitution shown in Figure 3 or 4 is adopted. In the constitution shown in Figure 3, condensing lenses (32)... are arranged between gas injection nozzles (25_1)~(25_n) so as to increase the power density of the laser beam passing directly above the nozzles. On the other hand, in the constitution shown in Figure 4 (an upper view), plural concave mirrors (33)... are used to increase the density of the laser beam passing through directly above the nozzles. In this way, by means of the apparatus shown in Figure 3 or Figure 4, it is possible to change the composition or particle size of the powder by controlling the type and pressure of reaction gas (23) of gas injection nozzles (25_1)~(25_n) and by adjusting the laser beam condensing characteristics so as to control the energy density.

Effects of the design

As explained in detail above, with the present design, it is possible to provide a type of fine powder manufacturing apparatus which can increase the energy efficiency and can manufacture powders of different particle sizes and types.

Brief description of the figures

Figure 1 is a diagram illustrating the powder manufacturing apparatus in an application example of the present design. Figure 2 is a diagram illustrating a powder manufacturing apparatus using a laser of the prior art. Figures 3 and 4 are diagrams illustrating the powder manufacturing apparatus in other application examples of the present design.

21	Reaction chamber
22	Optical window
23	Reaction gas
24	Inert gas
25_1-25_n	Gas injection nozzle
26_1-26_n	First nozzle
27_1-27_n	Second nozzle
28	Formed powder
29_1-29_n	Filter
30	Damper
32	Condensing lens
33	Concave mirror